§10. Reduction of Electron Heat Diffusivity Induced by Edge Cooling on LHD

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Turbulence in plasma can contribute to the non-linear dependence between heat flux and temperature gradient. Even if the heat flux has non-linear dependence, it is premised that the heat flux is determined by the local thermodynamic variables (e.g. temperature and its gradient). However, a few experiments have suggested that the electron heat transport is non-local. Interactions of turbulence over long distances are conjectured to provide the non-local mechanism. The clarification of the non-local mechanism is thus one of the most important issues in confinement studies. The magnetic configuration dependences of non-local transport play an important role in understanding its mechanism. In spite of the importance of comparison of the non-locality between Helical and Tokamak plasmas, it have not done yet because of no observation of the Tokamak-like strong non-local transport effect in Helical plasmas. A recent experimental progress on the transient electron transport has demonstrated a strong non-local effect of LHD plasmas as well as Tokamak one. A first result of the non-local transport analysis in helical plasma is presented.

The typical time evolution of electron temperature perturbation, δT_e, with non-local effect is shown in Fig. 1. The TESPEL is injected to the edge of ECH + NBI plasma (R_{ax} = 3.5m, B_{ax} = 2.83T, T_{e0} = 3keV, $\bar{n}_e = 1 \times 10^{19}\mathrm{m}^{-3}$). The cold pulse produced in the edge region ($\rho > 0.8$) is strongly reduced in the region of $0.4 < \rho < 0.6$, and thus neither temperature nor its gradient are changed significantly by the cold pulse propagation. In spite of no change in temperature and its gradient, a sudden rise of temperature is observed in the central region ($\rho < 0.4$).

The perturbated heat flux can be estimated by the following simple equation,

$$\delta q_e(\rho,t) = -\int_0^\rho \frac{3}{2} n_e \frac{\partial \delta T_e}{\partial t} dV. \qquad (1)$$

Here V is plasma volume and the density perturbation is neglected. Figure 2 shows the perturbed heat flux as a function of the perturbed temperature gradient for $\rho = 0.19$. The heat flux decreases suddenly after 4ms from TESPEL injection. The drop of heat flux is not involved with a change in $\nabla \delta T_e$, and thus is considered to be due to the reduction of heat diffusivity (forward transition). After the reduction of heat diffusivity, $\nabla \delta T_e$ is grown. However, this event is terminated and the heat diffusivity returns to normal level (Back Transition).

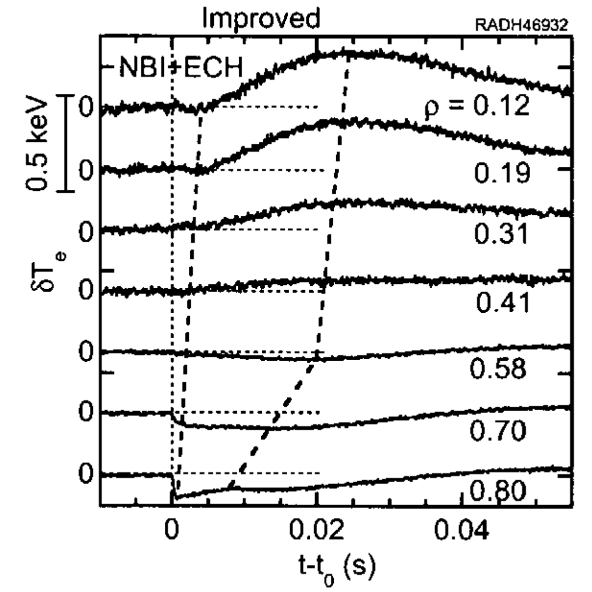

Fig. 1: Time evolution of electron temperature perturbations at different radii. The TESPEL is injected at $t = t_0$. The electron temperatures are measured with a 32-channel heterodyne radiometer. The plasma is optically thick except for the edge region and the ECE measurement is in good agreement with Thomson scattering measurement in this experiment.

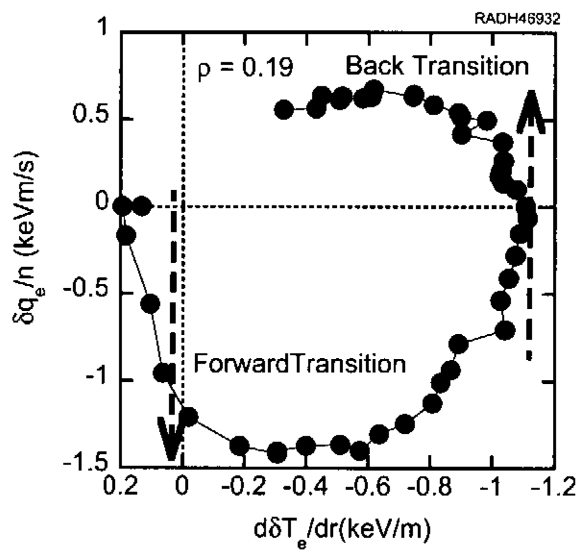

Fig. 2: Resurge of perturbed heat flux and perturbed temperature gradient at $\rho = 0.19$, here ρ is the nomalized average radius of closed magnetic surface. The perturbed heat flux is estimated by eq. 1 at every time step of 1ms after TESPEL injection.